Low Profile Tunable Dipole Antennas Using BST Varactors for Biomedical Applications

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Outline

- Motivation
- Background
- Previous Related Work
- 1-D Varactor based Tunable Antenna
- Summary
- Acknowledgement
- References

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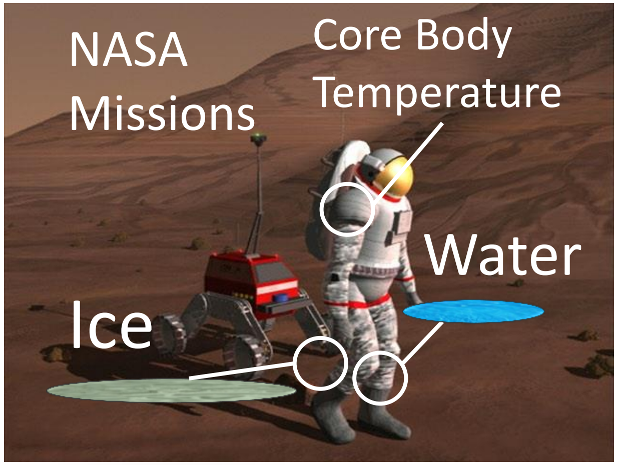
MOTIVATION

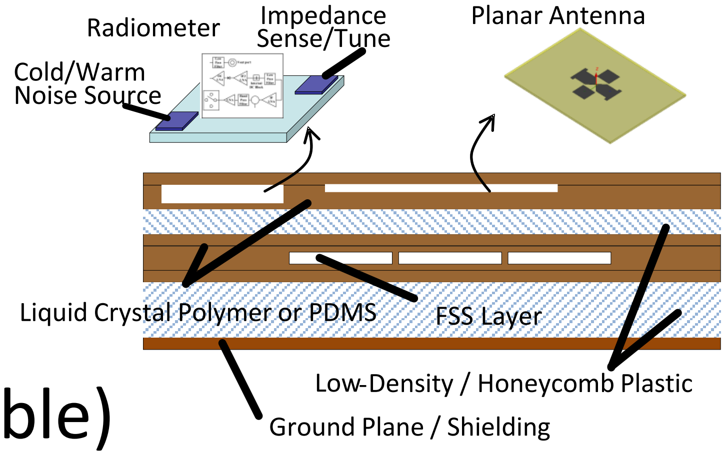
Motivation

- Design a low profile, conformal, tunable antenna for biomedical applications
- Portable radiometer applications:
  - Health monitoring sensor – astronauts, sports medicine, etc.
  - Remote Underground Thermal Detection

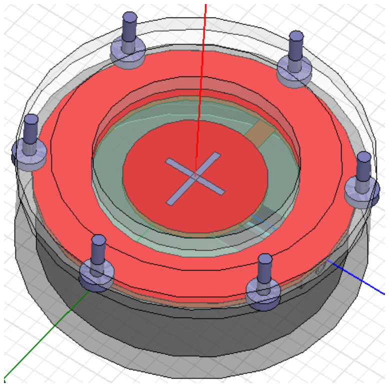


Motivation(Cont.)

- Antenna Requirements for wearable radiometer:
  - Minimize back-side radiation
  - Large bandwidth (~100 MHz)
  - Low profile and conformal (flexible)
  - Low weight, low cost & low complexity



27 mm height
~λ/8 at 1.4 GHz



Cavity-Backed Slot Antenna (CBSA)*
Cons: Bulky, heavy.

[*] Q. Bonds, T. Weller, B. Roeder and P. Herzig, "A tunable Cavity Backed Slot Antenna (CBSA) for close proximity biomedical sensing applications," in IEEE Microwaves, Communications, Antennas and Electronics Systems, 2009

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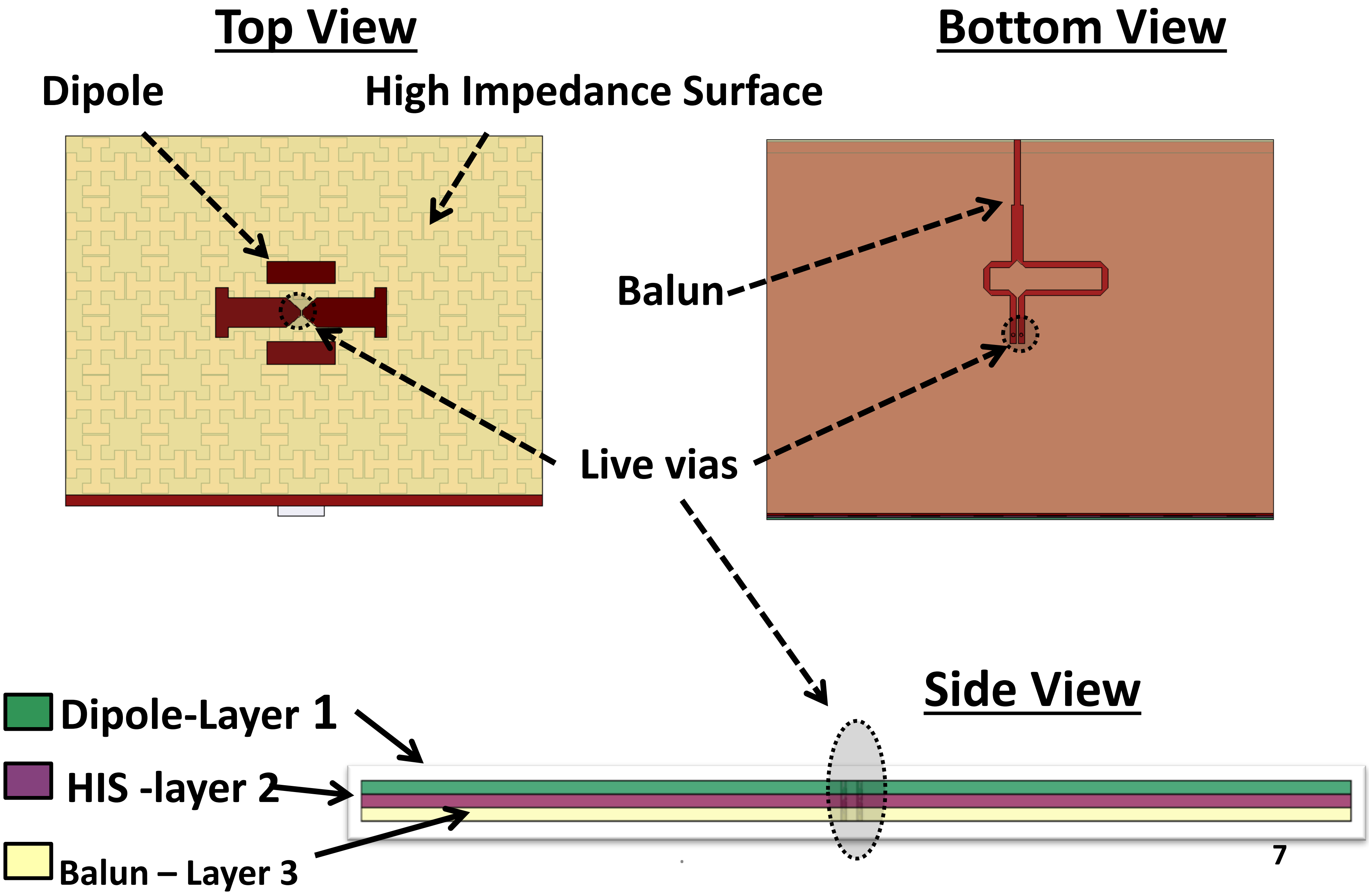
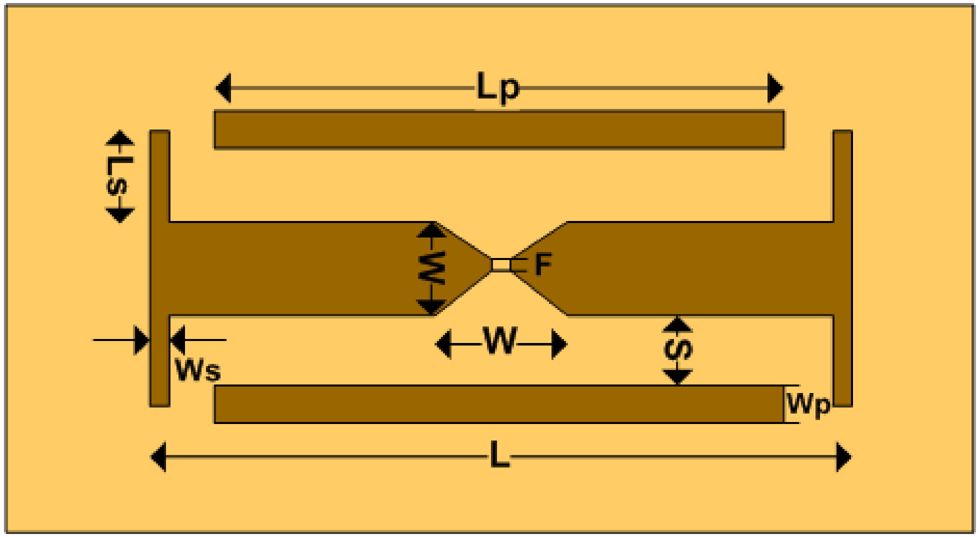
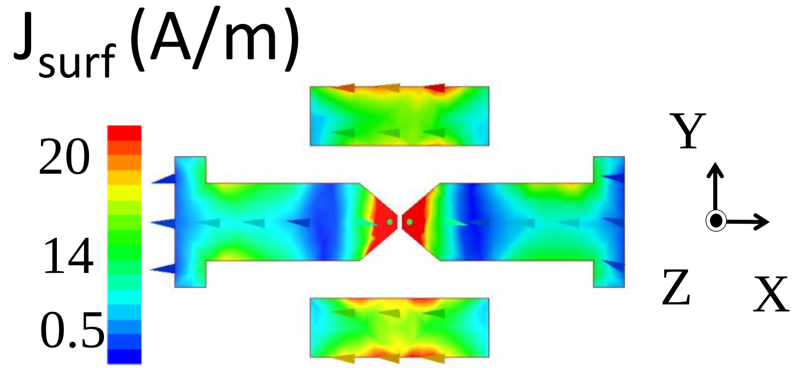
PREVIOUS WORKS

Antenna Structure

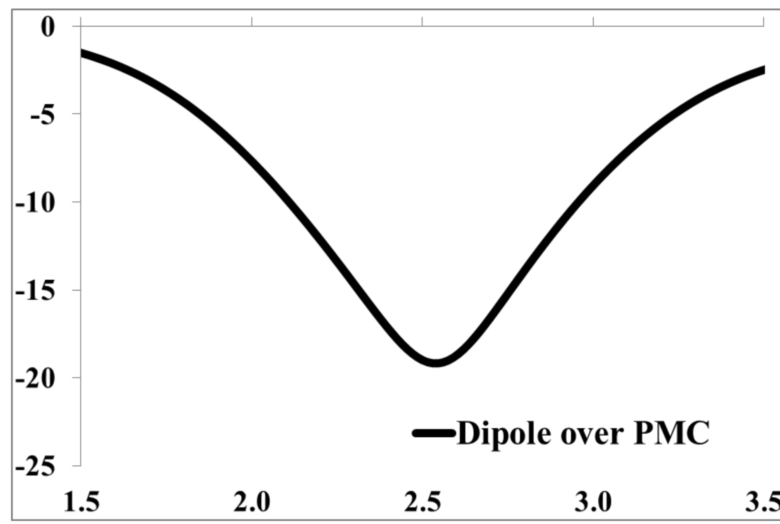


Dipole



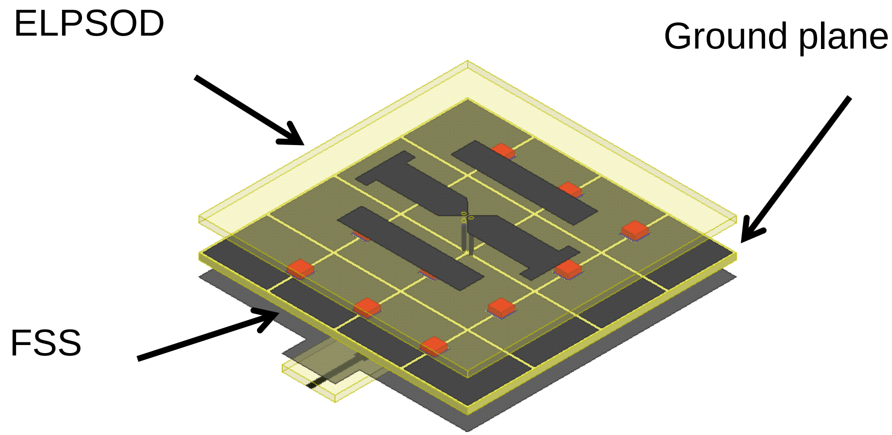


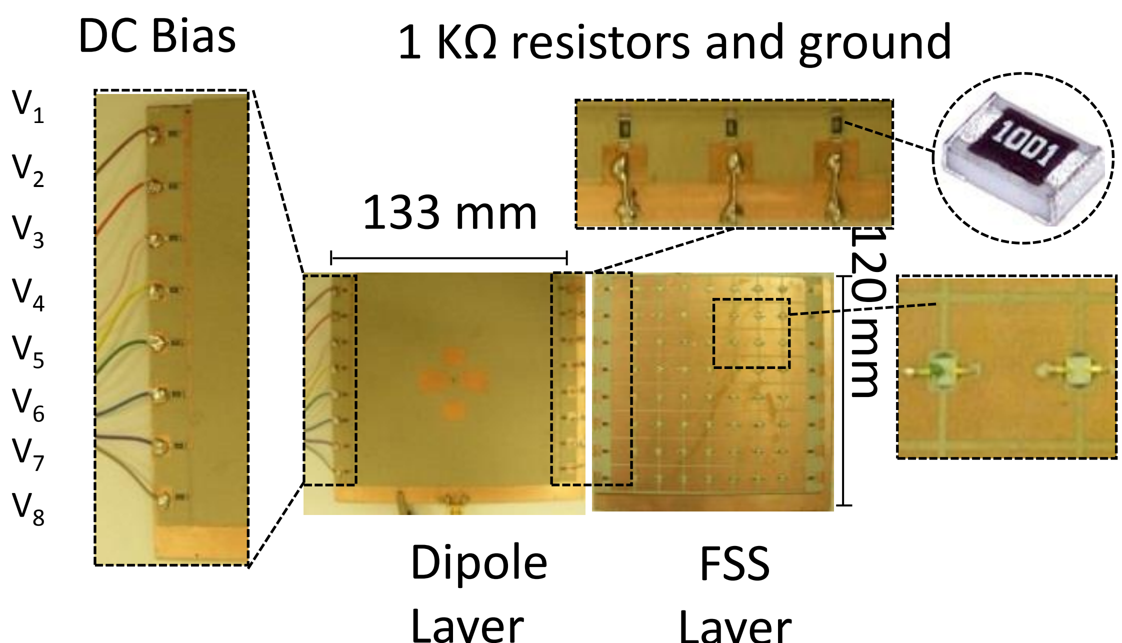
- End-Loaded Planar Open-Sleeve (ELPOSD)
- Broadband or dual response
- Tunable: Several parameters
- Lp affects the upper resonance frequency
- L affects the Lower resonance frequency



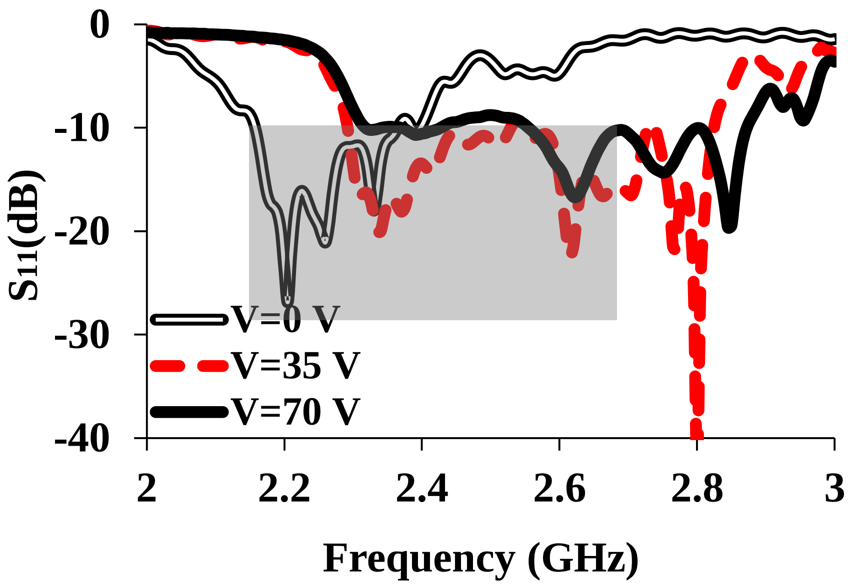
1-D Varactor based Tunable Antenna

- Height ~λ/45 at 2.4 GHz
- Bias and fabrication simplicity
- Minimize the use of vias (potentially conformal nature)
- High front-to-back radiation pattern ratio
- Ability to dynamically adjust the center frequency

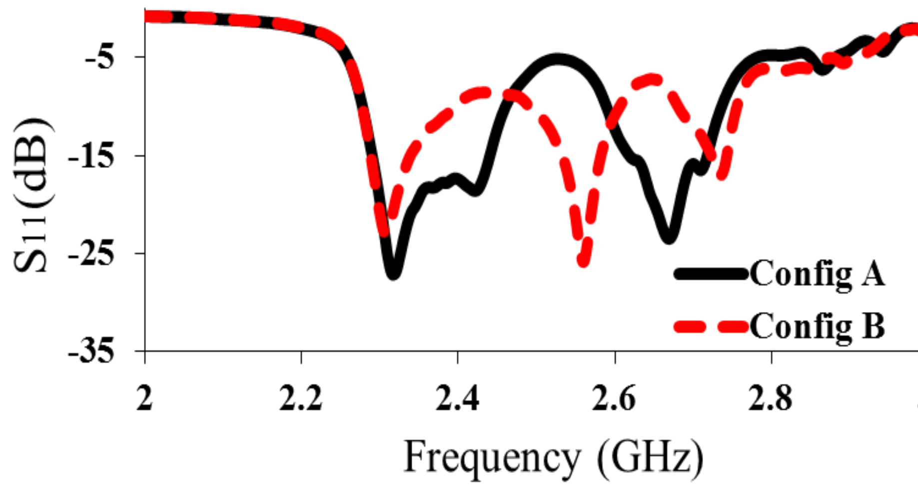


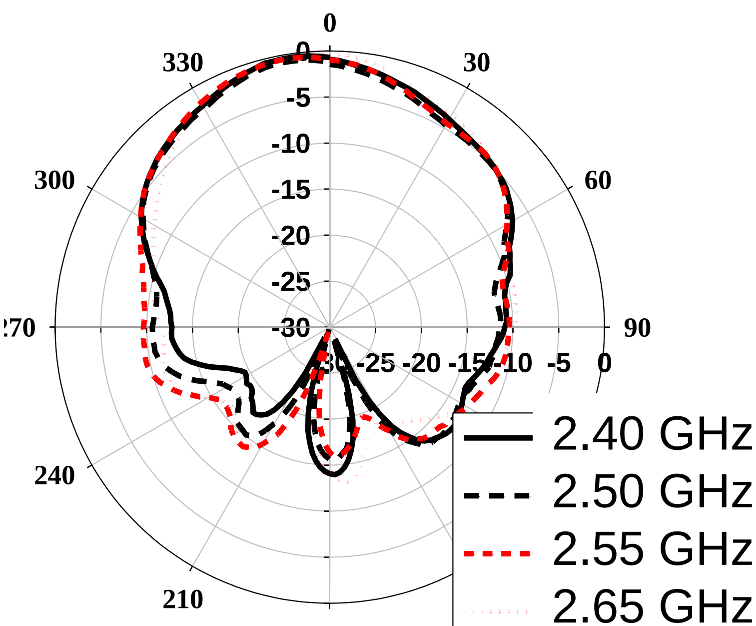


Common bias applied



Non-uniform bias voltages

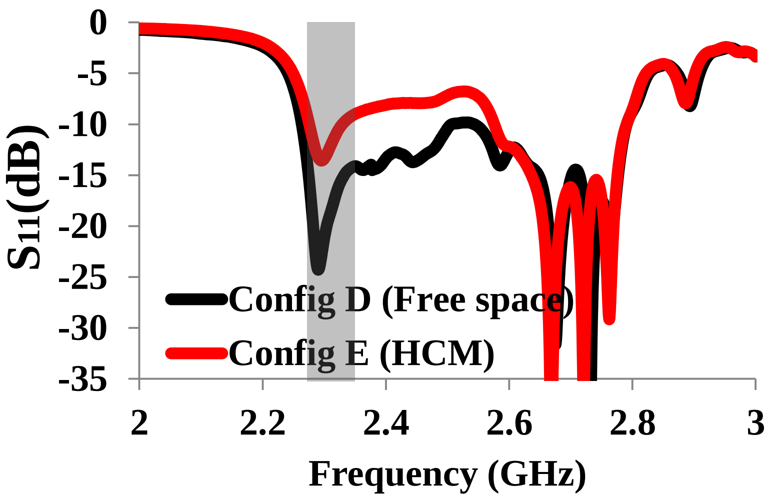


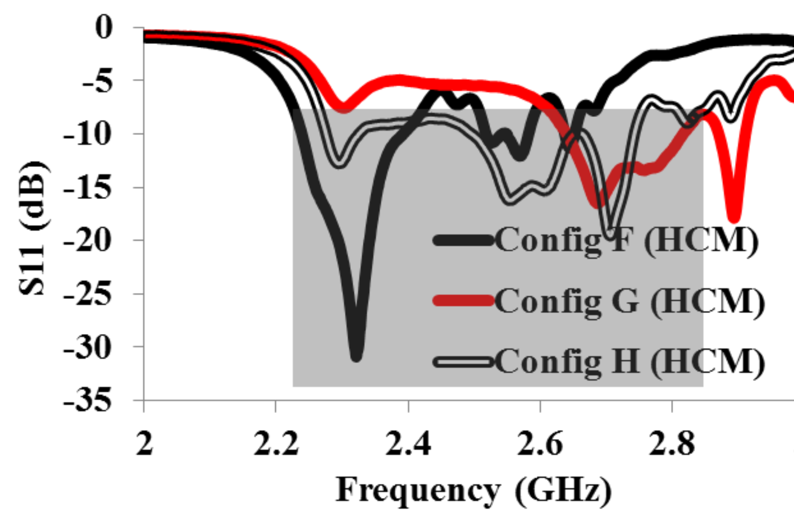


Config	V_1, V_2	V_3	V_4, V_5	V_6	V_7, V_8
A	30 V	30 V	30 V	30 V	30 V
B	70 V	70 V	30 V	70 V	70 V

Operation using non-uniform bias voltages with Human Core Model (HCM)

Config.	V_1, V_2	V_3	V_4, V_5	V_6	V_7, V_8
D (No HCM)	30 V	30 V	30 V	30 V	30 V
E (w/ HCM)	30 V	30 V	30 V	30 V	30 V
F (w/ HCM)	10 V	30 V	30 V	30 V	20 V
G (w/ HCM)	50 V	30 V	30 V	30 V	50 V
H (w/ HCM)	100 V	100 V	100 V	100 V	100 V



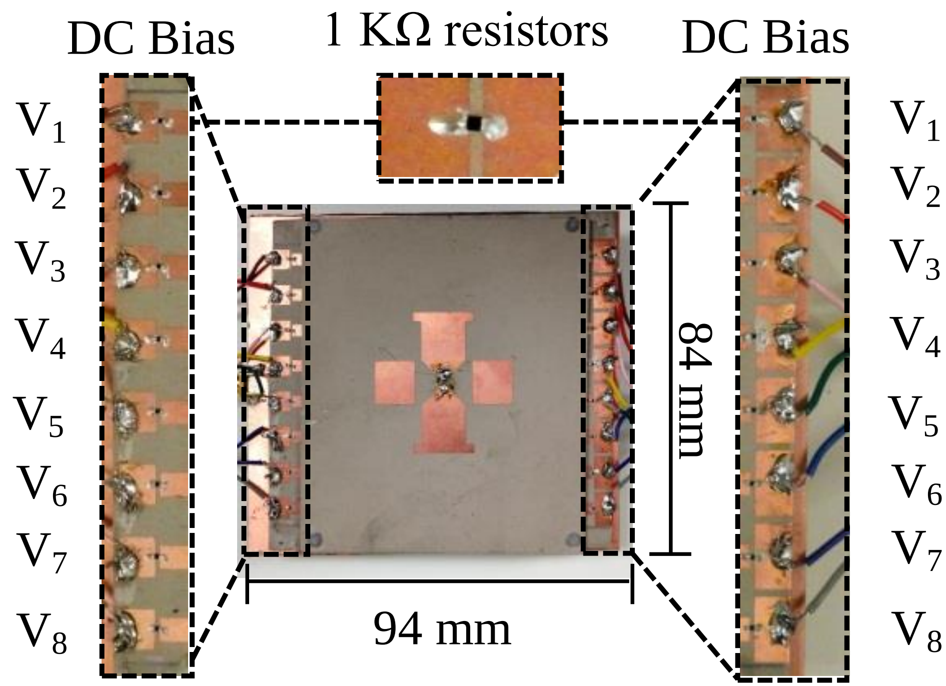


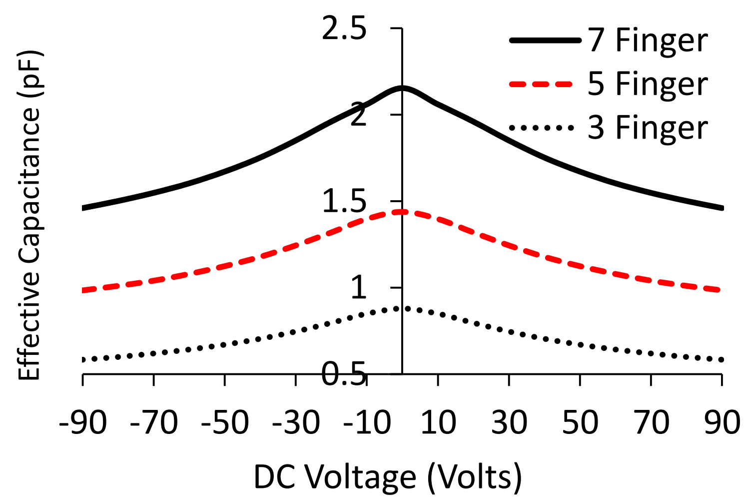
Low Profile Tunable Dipole Antennas Using BST Varactors for Biomedical Applications

1-D BST VARACTOR BASED ANTENNA

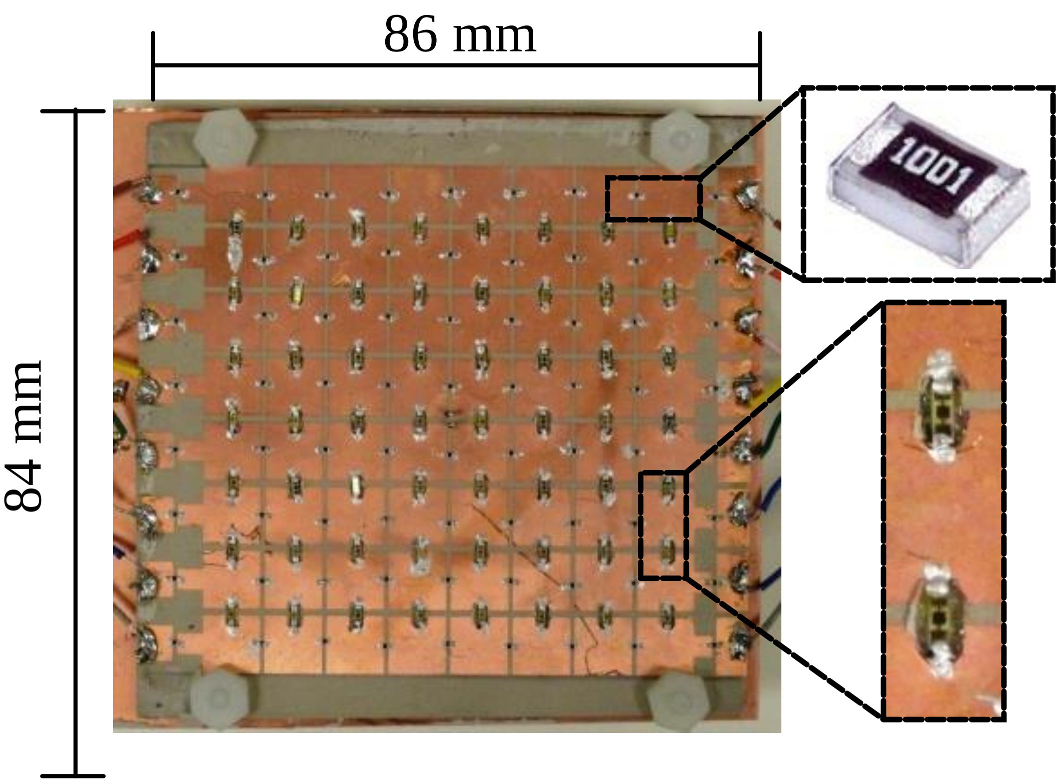
BST Varactor Based antenna

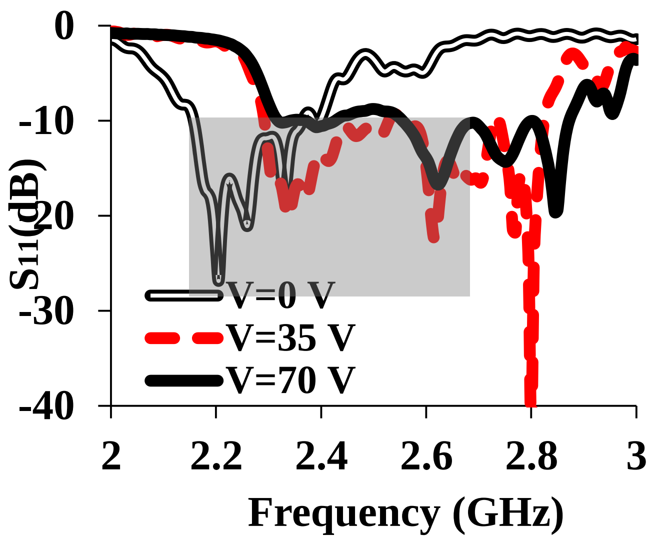
- Height ~λ/45 at 2.4 GHz
- Bias and fabrication simplicity
- Take advantage of the C-V symmetry curve
- Avoid the use of vias (potentially conformal nature)
- High front-to-back radiation pattern ratio
- Ability to dynamically adjust the center frequency

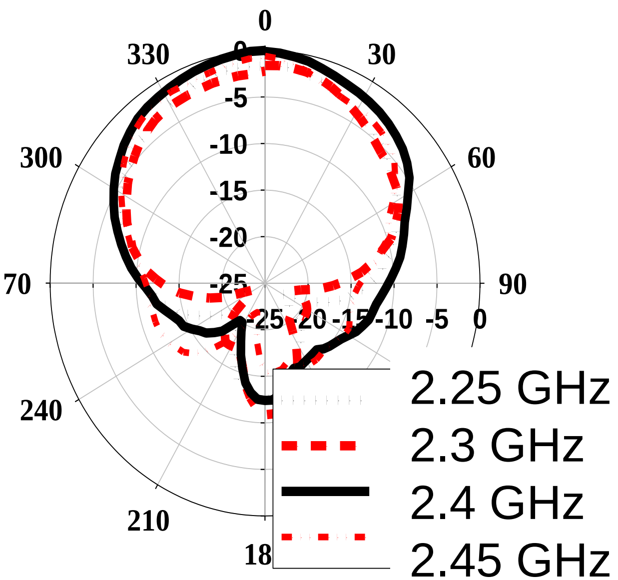




FSS Layer Using Barium Strontium Titanate (BST) Varactors



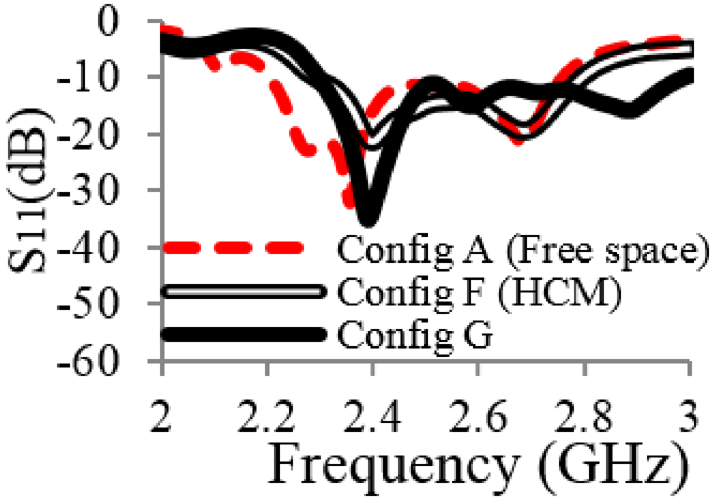




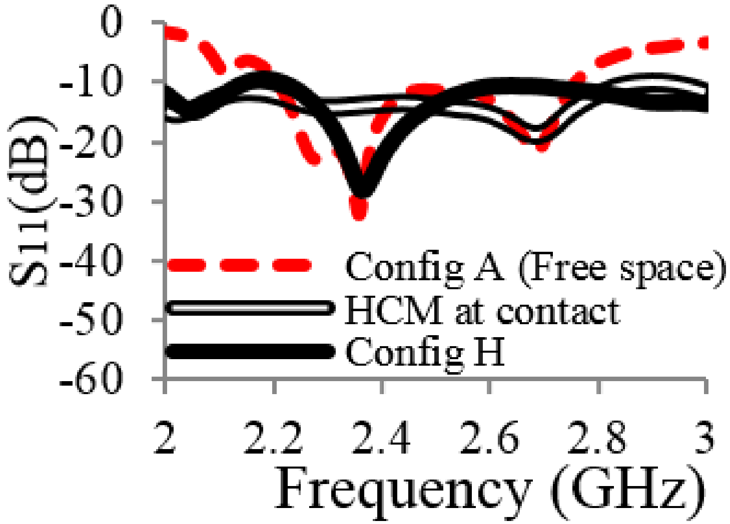
Operation using non-uniform bias voltages with Human Core Model (HCM)

Impedance match adjustment in:

- Close proximity to a HMC



- At contact with HMC



GaAs vs. BST antenna

Antenna	Mass (gms)	Total devices	Cost per device	Cost	Area (mm^2)	Eff. (%)	Tunable BW (MHz)
GaAs	188	56	50 US$	High	15600	50-80	520
BST	87	56	0.1 US$	Low	7900	30-60	425

- GaAs vs BST varactor based antenna
  - Both - low profile
  - Both - Easily tunable
  - BST - Reduced planar size and mass compared to GaAs
  - BST- Cost effective
  - BST - Compact and robust

Summary

- A low profile, tunable dipole antenna using BST varactors has been demonstrated
- The total antenna thickness is ~λ/45 when using 1-D varactor-loading
- A tunable frequency response from 2.2 to 2.55 GHz
- Cost effective, compact, robust, easily tunable and low profile antenna
- BST varactor antenna enables:
  - ❑ Small bias Network voltages
  - ❑ Potential use of flexible substrates

Acknowledgment

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- Wireless And Microwave Information System (WAMI) Center At University of South Florida

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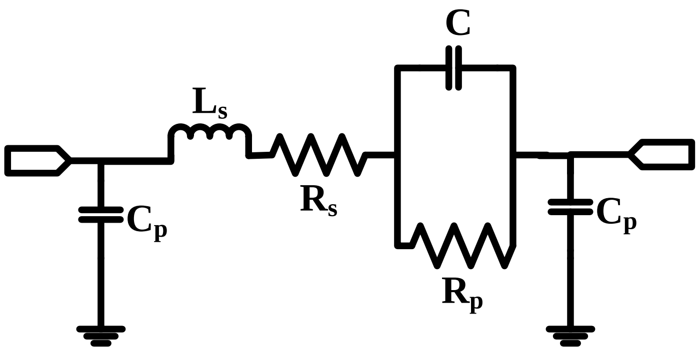
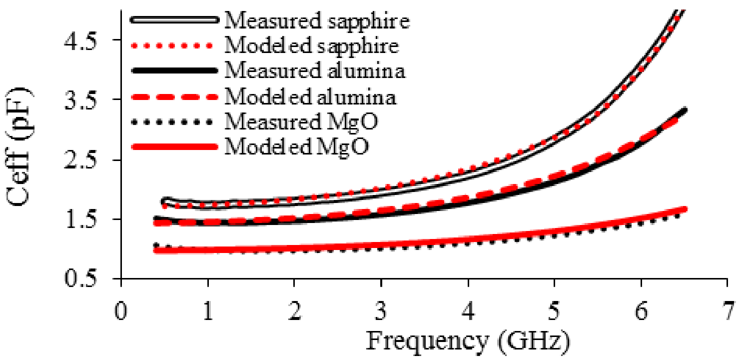
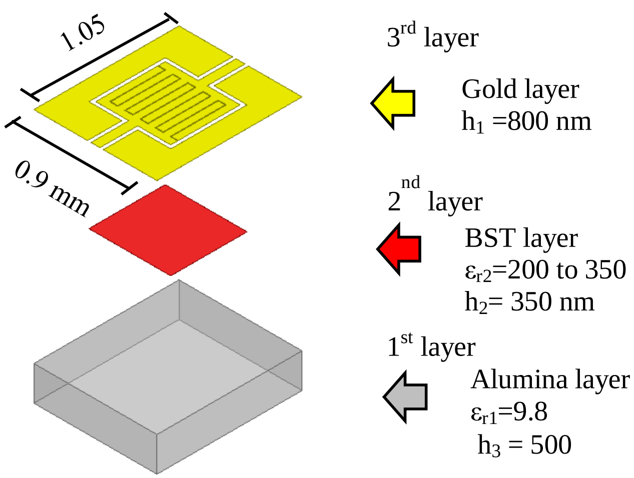
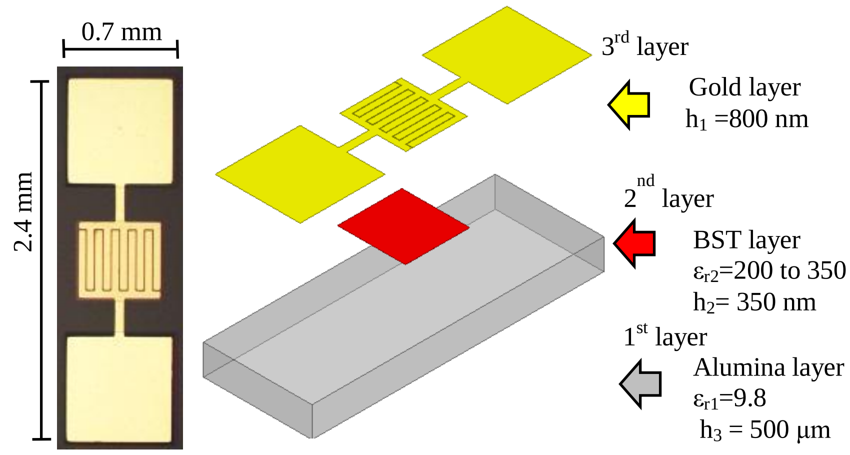
Add. 1 BST Varactor Characterization





Schematic for diode simulation.





(a) (b)

Add. 2

$$C_{end} = 4ns(2+\pi)\epsilon_{end}\varepsilon_0 \frac{K(\kappa_{0end})}{K(\kappa'_{0end})} \qquad (4.9)$$

54% error

$$C_{end} = 2ns\left(2+\frac{\pi}{2}\right)\epsilon_{end}\varepsilon_0 \frac{K(\kappa_{0end})}{K(\kappa'_{0end})} \qquad (4.10)$$

6 % error

Number of Fingers	Measured Effective Capacitance at 0 volts	Measured Effective Capacitance at 90 volts	Permittivity extracted at 0V and 90 V (HFSS)	Permittivity extracted at 0V and 90 (Eq. 4.09)	Permittivity extracted at 0V and 90V (Eq. 4.10)
3	1.17 pF	0.88 pF	800-500	400-250	750-510
5	2.1 pF	1.5 pF	750-500	450-270	770-500
7	3.2 pF	2.2 pF	750-500	470-270	800-520

Number of Fingers	Measured Effective Capacitance at 0 volts	Measured Effective Capacitance at 90 volts	Permittivity extracted at 0V and 90 V (HFSS)	Permittivity extracted at 0V and 90 (Eq.4.09)	Permittivity extracted at 0V and 90V (Eq.410)
3	0.75 pF	.5 pF	350-230	160-70	350-200
5	1.4 pF	0.98 pF	350-230	180-90	360-210
7	2.1 pF	1.45 pF	350-230	200-100	370-220